FUZZY AUDIO WIRELESS MUSIC SYSTEM

This is a continuation-in-part of application Serial No. 10/027,739 which patent application is pending.

BACKGROUND OF THE INVENTION

[0001] This invention relates to audio player devices and more particularly to systems that include headphone listening devices. The new audio system uses existing audio player device headphone jacks to connect a battery powered transmitter for wireless transmission of a signal to a battery powered receiving headphone.

[0002] Use of audio headphones with audio player devices such as radio, tape players, CD players, computers, television audio and the like have been in use for may years. These systems usually incorporate an audio source having a headphone jack to which a headphone may be connected by wire and connector.

[0003] There are also known wireless headphones that may receive A.M. and F.M. radio transmissions. However, these systems do not allow use of a simple plug in battery powered transmitter for connection to any audio player device jack, such as, laptop and desktop computers, portable compact disc players, portable MP3 players, portable cassette players and the like, for wireless transmission and reception of audio music for private listening to multiple users occupying the same space. Existing audio systems make use of electrical wire connections between the audio source and the headphones to accomplish private listening to multiple users.

[0004] There is a need for a battery powered simple connection system for existing audio player devices, to allow wireless transmission to a headphone receiver that accomplishes private listening to multiple users occupying the same space.

SUMMARY OF THE INVENTION

[0005] The present invention is directed to FAWM (Fuzzy Audio Wireless Music) systems for coded digital transmission of an audio signal from any audio player device with a headphone jack to a receiver headphone using fuzzy logic technology. A battery powered digital transmitter may include a headphone plug in communication with any of the previously mentioned audio sources, laptop and desktop computers, portable compact disc players, portable MP3 players, portable cassette players and the like. The FAWM system converts the audio music signal that may be supplied by the source, into a digital signal. This conversion takes place in the small battery powered transmitter that connects to the headphone jack of the source. The transmitter then adds a unique user code and transmits it to the battery powered receiver headphones where the fuzzy logic detector decodes only the unique user code to allow private listening without interference from other users.

[0006] These and other features, aspects and advantages of the present invention will become better understood with reference to the following drawings, description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 illustrates a schematic diagram representation of the FAWM system;

Figure 2 illustrates a graph of the high and low bit fuzzy logic if-then part fuzzy set according to an embodiment of the invention.

DETAILED DESCRIPTION

[0008] The following detailed description is the best currently contemplated modes for carrying out the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention.

[0009] Referring to Figure 1, a FAWM system 10 may include a battery powered transmitter 20 connected to a portable audio player or audio source 80. The battery powered transmitter 20 may be connected to the audio source 80 headphone jack 82 using a headphone plug 22. The battery powered transmitter 20 may have a transmitting antenna 24 that may be omni-directional for transmitting a coded digital modulated signal to a receiving antenna 52 of a battery powered receiver 50 that may be a headphone receiver. The battery powered receiver 50 may have headphone speakers 54 in headphones 55 for listening to the demodulated and decoded digital signal. The FAWM transmitter 20 may digitize the audio signal. This digital signal has a throughput of approximately 1.4 Mbps, which may be determined by the analog to digital A/D converter sampling rate of 44.1kHz multiplied by 16 bit quantization. To reduce the effects of channel noise, the battery powered transmitter 20 may use convolutional encoding, and interleaving. For further noise immunity, spread spectrum modulation may be utilized. The battery powered transmitter 20 may contain a shift register generator (SRG) that may be used to create a unique user code. The unique user code generated is specifically associated with one FAWM user, and it is the only code recognized by the battery powered FAWM headphone receiver 50 of that particular user. The radio frequency (RF) spectrum utilized (as taken from the Industrial, Scientific and Medical (ISM) band), may be approximately 2.4 GHz. And the power radiated by the transmitter adheres to the ISM standard.

[0010] Referring to Figure 1, the digital modulated signal from transmit antenna 24 may be received by receiving antenna 52 and then demodulated,

decoded and deinterleaved in the battery powered receiver 50 headphones. The battery powered receiver 50 may utilize fuzzy logic to optimize the detection of the received user code.

[0011] Each receiver 50 user may be able to listen (privately) to high fidelity audio music, using any of the audio devices listed previously, without the use of wires, and without interference from any other receiver 50 user. Because of the fuzzy logic detection technique used in the wireless digital audio system, user separation through code division may be achieved.

[0012] The battery powered transmitter 20 sends the audio information to the battery powered receiver 50 in digital packet format. Each packet may consist of, at minimum, a start bit to indicate the beginning of a packet, the unique user code, the digitized audio information and a stop bit to indicate the end of a packet. These packets may flow to create a digital bit stream rate less than or equal to 1 Mb/s.

[0013] The user code bits in each packet may be received and detected by a fuzzy logic detector in the headset receiver 50. For each consecutive packet received, the fuzzy logic detector may compute a conditional density with respect to the context and fuzziness of the user code vector, i.e., the received user code bits in each packet. The fuzzy logic detector is the key component to the FAWM system 10. Because the fuzzy logic detector enables the battery powered FAWM receiver 50 to accurately detect the assigned user code in the presence of noise, which includes other FAWM users. Fuzziness may describe the ambiguity of the high (1)/low (0) bit event in the noisy received packet. Note that the fuzzy detector may measure the degree to which a high/low bit occurs in the user code vector, which produces a low probability of bit error in the presence of noise. The fuzzy detector may use a set of if-then rules to map the user code bit inputs to validation outputs. These rules may be developed as if-then statements.

[0014] The fuzzy logic detector in the battery powered receiver 50 utilizes the if-then fuzzy set to map the received user code bits into two values; a low

(0) and a high (1). Thus, as the user code bits are received, the "if" rules map the signal bit energy to the fuzzy set low value to some degree and to the fuzzy set high value to some degree. See Figure 2. Due to additive noise each user code bit (bit energy x) may have some membership to a low and high as represented in Figure 2. Therefore, the if-part fuzzy set may determine if each bit in the user code, for every received packet, has a greater membership to a high bit representation or a low bit representation. The more a user code bit energy, x fits into the high or low representation, the closer its subsethood, i.e., a measure of the degree to which a set may be a subset of another set, may be to one. Note that Figure 2 shows that -1 equals the maximum low bit energy representation and 1 equals the maximum high bit energy representation to illustrate that this design may utilize Manchester encoding/decoding schemes.

[0015] The received user code input bit in each packet may be:

x(i), where i = 1,2, ..., n is the set of all bits that make up the user code vector.

X(c), where c = 1, 2, ..., m represents each user assigned a unique user code.

So user X(1) has bit code [x(1) x (2) .....x(n)] and user X(m) has bit code [x(1) x (2) ....x(n)] which is different from user X(1).

[0016] Each x in X may activate a fuzzy "if" rule. The if-part sets may be conditional densities, so the fuzzy "if" rule activates to the degree p[x(i)lX(c)] p[X(c)], which is the probability of the user code bits x given the user vector X multiplied by the probability of X.

[0017] The then-part fuzzy rule set may be indirectly dependent on the input bits x in X. The then-part set may be a weighted sum equal to p[x(i)] p[ylx(i), i = 1, 2, ...,n.

[0018] Which is the probability of the user bit vector x multiplied by the probability of y given the user bit vector x. Where y may be a number representation to define the correct user headset battery powered receiver 50

given the input bit set x(i), I = 1, 2, ...,n.

[0019] The if-then rule parts that make up the fuzzy logic detector must be followed by a defuzzifying operation. This operation reduces the output fuzzy set to a single number that determines if the correct received user code bits within the transmitted packet have been detected. The defuzzifying operation may be implemented with the modal method, i.e., calculation of the value that has the highest membership in the fuzzy set. With the modal method a strategy of clarity may be applied in the event that some user code energy bit values have equally high membership. The clarity of a fuzzy set may be considered by weighting the conditional densities discussed previously. The weighting determines relative fuzziness of the user code energy bit (x) that gives a measure of the uncertainty of the unique user code vector. As a result, the fuzzy logic detector used in the battery powered headset receiver 50 greatly reduces the unique user code bit error probability. The fuzzy logic detector technique, combined with convolutional error detection and correction techniques, may enable the FAWM system 10 to operate in most any environment.

[0020] While the invention has been particularly shown and described with respect to the illustrated and preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.